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Book Reviews

Theory of Recycle Processes in Chemical Engineering. By M. F. Nagiev, MacMillan, New York, N. Y., (1964). 278 pp. $15.00.

This monograph is a translation from the 1958 Russian text of the same title. It might best be described as a unified treatment of the research performed by the author and his co-workers on the subject of recycle calculations in process flow-sheets. A recycle process is defined as one in which portions of reactor effluent streams are returned to the original reactors, or used as portions of the feed stock for other reactors. The recycle theory is based on writing the material balances in the form of simultaneous linear equations, and the formulation of these equations is given in quite general form. To the best of the reviewer's knowledge, it represents the first consistent, self-contained and reasonably complete exposition of the subject matter.

The text has numerous strong points which make it a valuable tool for recycle calculations. Considerable attention is given to the case where the yields realized in the process reactors are dependent upon the composition of the total reactor charge, as well as to the more simple case where the conversion of reactants is independent of their concentration in the charge. To deal with the former class of problems, the author develops a systematic theory of making-up mixtures. The theory is then utilized to show that the system of simultaneous equations generated by the material balances is determinate. The basis of this theory is the demonstration that the addition of a particular component in the fresh reactor feed may always be taken as zero.

Numerous practical examples of flowsheet calculations, performed using the general recycle equations, are given. In addition, the author devotes an entire chapter to the problem of *laboratory* determination of the conversions which can be expected from the commercial-scale, continuous reactor with recycle. These laboratory methods are valuable because they rely on batch-type experiments only.

In the last chapter of the book the author selects propylene hydrochlorination as a reaction for illustrating the advantages of the recycle method over multi-stage processing in obtaining maximum yields from given reactor volumes. Several possible flowsheets are compared, and the recycle flowsheets are demonstrated to have significantly higher efficiencies. It is unfortunate that the general recycle theory developed earlier in the text is not of great utility in these examples, which are worked largely by ordinary methods of reactor design.

Some of the weak points of this work may also be noted. The quality of printing, and in particular the reproduction of the figures, is considerably below average for a technical text. The recycle theory ultimately results in a large system of linear equations, which may require solution by iteration. The questions of convergence and rate of convergence are not even mentioned by the author. Furthermore, there is no way of comparing the algorithm computationally with others which have been presented in the recent literature, because the Russian text predates these.

Another weakness of the method presented is that no explicit provision is made for use of nonlinear kinetic equations. In order to use the author's method, one must first prepare, from the kinetic rate expressions, correlations of conversion as a function of feed composition and reaction temperature. The question of temperature is completely ignored since no treatment is given of energy balances.

This reviewer found that the nomenclature was generally unwieldy, the major fault being the proliferation of subscripts, primes and braces. This appears to be one case in which the use of matrix notation would have greatly aided the clarity of presentation, by emphasizing the basic nature of the equations. To cite an extreme example of the tedious nomenclature, in the general recycle theory the conversions appear with three subscripts, one of which has a further subscript, and two of which are primed. An additional obstacle to reading this text is provided by the frequently inferior sentence construction. As an example, consider the statement, "If a multi-component mixture is to be made-up to the required composition by means of minimum quantitative additions and diminutions of its components, then the change of that component, among those designated for addition, in the case of which the criterion of making-up mixtures is the maximum, should be taken as zero." It is not known to this reviewer whether the cause is a literal translation of the Russian, or the literary style of the translator.

As an overall evaluation, this work should seem to be a required reference for anyone desirous of systematizing flowsheet material balances, particularly on an automatic computer, or anyone intending to do further research on this subject.

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About the Reviewer: Lowell B. Koppel received his Ph.D. in chemical engineering from Northwestern University in 1960. He served one year on the Chemical Engineering Staff at the California Institute of Technology, and then joined the School of Chemical Engineering at Purdue University where he now holds the rank of Associate Professor. He has authored papers on heat transfer, process control and systems engineering, and is co-author of a recent text on process control. During the last two years he has served as Consultant to Argonne National Laboratory.